

# Long-Term Functional Outcome of Telestroke Patients Treated Under Drip-and-Stay Paradigm Compared with Patients Treated in a Comprehensive Stroke Center: A Single Center Experience

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## Abstract

**Objective:** The purpose of this study is to compare long-term functional outcome for patients who receive intravenous alteplase (tPA) at a primary stroke center (spoke) through telestroke consultations and remain at the spoke (drip-and-stay) with that for patients who receive tPA at the comprehensive stroke center (hub).

**Methods:** Data on baseline characteristics, stroke severity on presentation, door to needle (DTN) time, the rate of symptomatic intracerebral hemorrhage (sICH) and long-term outcomes for all patients evaluated at the Medical University of South Carolina (MUSC) hub and MUSC telestroke network spoke sites between January 2016 and March 2017 were collected. Eligible patients received tPA at either the spoke or hub location during the study period. Patients who received mechanical thrombectomy were excluded from the study. Functional outcome was assessed with 90-day modified Rankin Scale (mRS). Descriptive statistics were used to compare patient demographics and clinical outcomes across the two groups.

**Results:** Total of 426 were identified (60 hub patients and 366 drip-and-stay patients). There were no significant differences in patient age, sex, admission National Institute of Health Stroke Scale (NIHSS), sICH, or DTN times between the two groups. mRS of 0–2 at 90 days was achieved in 37 (61.7%) of

the hub and in 255 (69.7%) in the drip-and-stay patients ( $p=0.216$ ). On regression analysis, there was no difference in the adjusted relative risk of having a lower mRS between drip-and-stay and hub patients (incidence rate ratio 1.14,  $p=0.278$ , 95% confidence interval [0.9–1.43]).

**Conclusion:** Our study shows no difference in the long-term functional outcome for patients who received tPA through telestroke consultation and remained at spoke hospitals (drip-and-stay) compared with patients who received tPA at the hub.

**Keywords:** ischemic stroke, telestroke, drip-and-stay, functional outcome

## Introduction

Intravenous thrombolysis using tPA is the current standard of care for patients present with acute ischemic stroke (AIS) presenting within 4.5 h of the last known well time.<sup>1,2</sup>

Previous studies showed that the benefit of tPA is time-dependent and faster tPA administration is associated with better long-term functional outcome and a lower rate of complication rates.<sup>3–8</sup> The implementation of telestroke has made it feasible for patients living in rural areas to get access to expert stroke opinion and receive tPA at primary stroke center (PSC; spoke) without the need to be transferred to comprehensive stroke center (hub).<sup>9,10</sup>

The safety and efficacy of administering tPA through telemedicine networks have been established before.<sup>11</sup> Patients who received thrombolytic treatment through telestroke have similar rates of mortality and symptomatic intracerebral hemorrhage (sICH) to those who receive it in person at a primary or comprehensive stroke center.<sup>10,12</sup> Moreover, Schwab et al. reported no difference in the 6 months functional outcomes between patients who received tPA at a comprehensive stroke center and patients who received tPA as spoke and transferred to the hub (drip-and-ship).<sup>13</sup> Limited data are available on patients who receive tPA at a spoke site and remain there for post-tPA care (drip-and-stay). The purpose of this study is to compare the complication rates and long-term

functional outcome of telestroke patients who are treated under the drip-and-stay paradigm with those treated at a comprehensive stroke center.

**Methods**

**SETTING AND DATA SOURCES**

The Medical University of South Carolina (MUSC) telestroke program was started in 2008 and has evolved since then to include 26 partner hospitals in a hub-and-spoke model.<sup>14-16</sup> Figure 1 shows the spoke sites for MUSC telestroke program throughout the state of South Carolina.<sup>17</sup>

The MUSC hub maintains a registry of patient information, process measures (e.g., door to needle [DTN] times), and outcomes from the telestroke consultations at spoke sites. In January 2016, the MUSC hub implemented a new process to

follow-up with all telestroke patients to collect 90-day modified Rankin Scale (mRS), including those who do not transfer. The 90-day functional outcome was recorded at clinic visits or through telephone interviews with an experienced nurse practitioner or stroke neurologist. A total of three attempts are made to collect the postdischarge information.

The following patient variables were exported for this study: age, sex (m/f), race, National Institute of Health stroke scale (NIHSS) on presentation, DTN time in minutes, the occurrence of sICH following administration of tPA (Y/N), and mRS after 90 days of discharge (0-6). Eligibility for tPA was based on the 2013 AHA acute stroke management guidelines at either the spoke or hub location during the study period.<sup>1</sup> sICH was defined as per the European Cooperative Acute Stroke Study (ECASS) II: any intracerebral hemorrhage on any



**Fig. 1.** MUSC telestroke spoke locations. MUSC, Medical University of South Carolina.

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**Table 1. Baseline Demographic Characteristics of the Study Cohort**

PATIENT CHARACTERISTICS	HUB GROUP (N=60)	DRIP-AND-STAY GROUP (N=366)	p
Mean age in years (SD)	67.6 (14)	67.6 (16.1)	0.977
Sex, n (%)			0.234
Female	30 (50)	213 (58.2)	
Male	30 (50)	153 (41.8)	
Race, n (%)			0.321
White	33 (55)	226 (61.8)	
Non-White	27 (45)	140 (38.3)	
NIHSS Admission Score			
Mean (SD)	9.38 (7.3)	9.83 (7.4)	0.668
Median (IQR)	7 (4–12)	7 (4–14)	0.758
Mean door to needle time in minutes	68.3	61.3	0.165
sICH, n (%)	1 (1.09)	4 (1.67)	0.534
mRS, n ()			0.216
0–2	37 (61.7)	255 (69.7)	
3–6	23 (38.3)	111 (30.3)	
IQR, interquartile range; mRS, modified Ranking Scale; NIHSS, National Institute of Health Stroke Scale; SD, standard deviation; sICH, symptomatic intracerebral hemorrhage.			

post-treatment imaging after the start of tPA and increase of  $\geq 4$  NIHSS points.<sup>18</sup> The variables were exported, from the electronic medical record (Epic) for hub patients and the telestroke registry for spoke patients, and the two datasets were combined. The study includes data for patients treated with tPA at the hub and spokes between January 2016 and March 2017. Data from three of the spoke centers were not complete so we did not include patients seen in these centers in the analysis. One hundred and seventeen patients were excluded from the drip-and-stay group for the following reasons: suspected or confirmed large vessel occlusion (11 patients), or missing admission or 90 days mRS (103 patients), NIHSS score on presentation (1 patient), or DTN time (2 patients). Eighteen patients were excluded from the hub group because they received mechanical thrombectomy.

### OUTCOME MEASURES

We examine three different patient outcomes in this study: (1) functional outcome; (2) occurrence of sICH (where 1 in-

dicates yes, and 0 indicates no); and (3) mortality (where mRS of 6 was coded as 1 and mRS  $< 6$  coded as 0).

Functional outcome was assessed using 90-day mRS. We classified patients across two mRS outcome categories. A good outcome was defined as mRS 0–2, and poor outcome was defined as mRS  $> 2$ , a cutoff that has been used previously in the literature.<sup>19</sup>

### DATA ANALYSIS

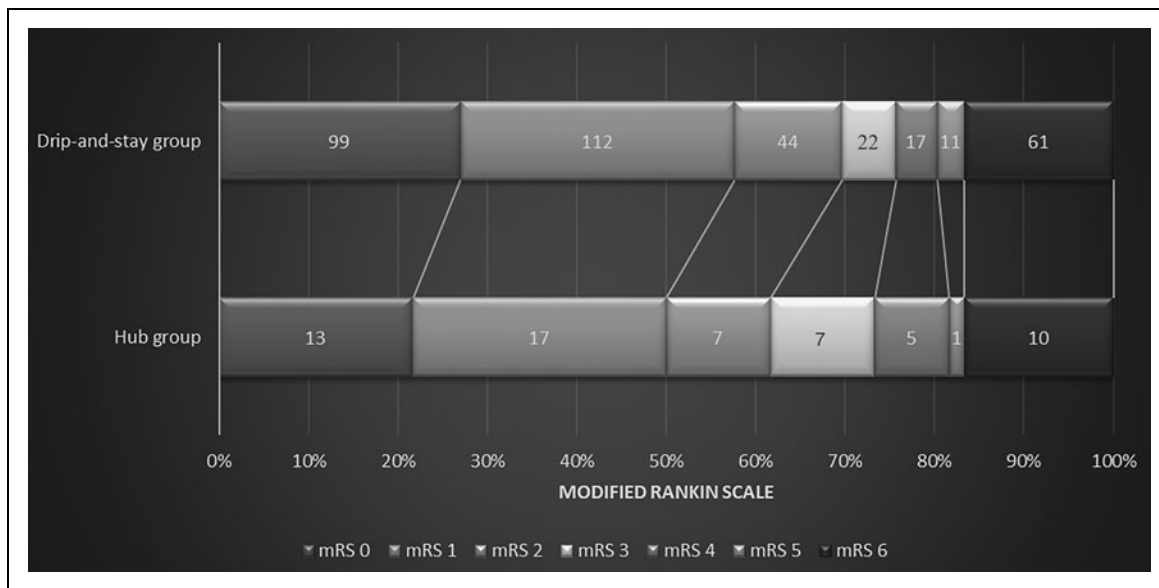
Descriptive statistics were used to compare patient demographics and clinical outcomes across the two groups (hub and “drip-and-stay”). As appropriate, *t* test were used for normally distributed interval variables, chi-square was used for categorical variables, and Wilcoxon Mann Whitney tests for nonparametric interval variables. To predict the relative risk (RR) of an outcome for drip-and-stay patients compared to the hub, adjusting for patient stroke severity (NIHSS), DTN time, age, sex, and race, we estimated a modified poisson regression with robust error variance. An RR model is preferred over logistic regression odds ratios when the outcome is common ( $> 10\%$ ). Traditional logistic regression was also tested for each model, there were no differences in outcomes, and therefore the RR model is reported to provide the most conservative results.<sup>20</sup> Approval of the institutional review board was obtained. Data analysis was conducted using Stata 14.2 software.

### Results

A total of 426 patients are included in the study. Three-hundred and sixty-six patients received intravenous (IV) tPA at spoke center and remained there (drip-and-stay group). In the hub, 60 patients received IV tPA and were admitted to the comprehensive stroke center (hub group). Baseline demographic characteristics of the two groups are outlined in *Table 1*.

There were no significant differences in patient demographics between the two groups. The mean age for both groups was 67.6 years. Thirty (50%) patients were female in the hub group versus 213 (58.2%) in the drip-and-stay group,  $p=0.23$ . Median admission NIHSS was 7 for both groups and the mean NIHSS was 9.83 for the drip-and-stay group and 9.38 for the hub group ( $p=0.668$ ). Mean DTN time was 61.3 min for the drip-and-stay group and 68.3 min for the hub group ( $p=0.165$ ). sICH was observed in 1 (1.09%) patient in the hub and 4 (1.67%) in the drip-and-stay group ( $p=0.534$ ).

Good long-term functional outcome (mRS of 0–2 at 90 days of discharge) was achieved in 37 (61.7%) patients in the hub group, and 255 (69.7%) patients in the drip-and-stay group ( $p=0.216$ ) (*Fig. 2*). Unadjusted comparison also found no difference in the percentage of patients who had expired 90 days



**Fig. 2.** Long-term outcomes comparison of the drip-and-stay group and hub group. mRS, modified Rankin Scale.

postdischarge, with 16.67% of patients in each group (61 patients in the drip-and-stay group and 10 patients in the hub group) having a 90-day mRS of 6. In the regression results, there was no difference in the RR of having a lower mRS between drip-and-stay and hub patients (RR 1.137,  $p=0.278$ , 95% confidence interval [0.9–1.43]). Other independent predictors of good functional outcomes include younger age ( $p<0.001$ ) and lower NIHSS on presentation ( $p<0.001$ ) (Table 2).

**Discussion**

In this study, we found no difference in the complication rate or long-term functional outcomes between patients treated under the drip-and-stay paradigm compared with patients treated

in a comprehensive stroke center. These results confirm the already established effectiveness of thrombolysis treatment through telestroke and add that patients managed in spoke sites have similar long-term functional outcome compared with the comprehensive stroke center.<sup>21,22</sup>

Limited literature is currently available that assesses the quality of care provided for AIS patients at the spoke sites. A study by Heffner et al. evaluated patients who stayed at a spoke site after receiving thrombolysis (drip-and-stay).<sup>23</sup> Authors compared functional outcomes between 134 drip-and-stay patients and 272 patients who received thrombolysis at a comprehensive stroke center. The authors concluded that the drip-and-stay group of patients had a higher risk of long-term mortality even though they had a less severe stroke with lower NIHSS on presentation.<sup>23</sup> Our study showed no difference in either the stroke severity defined by NIHSS on arrival or in the 90-day mortality rate (mRS of 6). Both groups had 16% mortality rate. Additionally, we found no difference in the number of patients achieving good long-term functional outcome between the two groups.

Multiple factors are considered for patients who receive tPA through telestroke consultation. A recent study by Yaghi et al. has shown no difference in good outcome (mRS 0–2) between patients who were admitted to the spoke sites after tPA (drip-and-stay) and patients who were transferred to the hub (drip-and-ship).<sup>24</sup> The same study showed that patients with moderate to severe stroke (defined by NIH stroke scale more than 8 on presentation) had better outcomes if they were transferred to the hub.<sup>24</sup> In our study, the median NIHSS on admission was 7 in both the telestroke intervention and standard hub groups, and patients in the drip-and-stay group had similar complication rates and good functional outcome to those managed at the comprehensive stroke center. Given that PSC certification is known to be associated with better care and outcome, a possible explanation to the difference between our

**Table 2. Regression Analysis to Predict Good Functional Outcomes**

OUTCOME	RELATIVE RISK	ROBUST SE	<i>p</i>	95% CI	
Drip-and-stay	1.14	0.13	0.278	0.9	1.43
Admit NIHSS	0.96	0.01	<0.001	0.95	0.97
Door to needle time	1	0.001	0.727	1	1
Age	0.99	0.001	<0.001	0.98	0.99
Female	0.96	0.06	0.501	0.086	1.08
White	1.11	0.07	0.097	0.98	1.25

CI, confidence interval; SE, standard error.

results and the results of the studies reported by Heffner et al. and Yaghi et al. is the fact that most of the spoke sites included in the study have PSC certification. Additionally, drip-and-stay patients who received IV tPA through MUSC telestroke network receive a follow-up consultation during their hospital stay through our teleneurology network that might have contributed to the observed good outcome. Given that all patients who receive tPA through MUSC telestroke network receive physical therapy evaluation and treatment during their hospital stay at spokes, and many of these patients are discharged to rehabilitation facilities, the quality of which plays a significant role in recovery and therefore long-term outcome. The excellent long-term outcome in our spokes also reflects the great quality of rehabilitation services those spokes provide.

Our study findings are particularly important in the current era of mechanical thrombectomy.<sup>25–31</sup> Patients who were admitted to spoke sites had similar outcomes to those admitted to a comprehensive stroke center. From these findings, we conclude that stroke patients receive quality of care and quality of rehabilitation at spoke sites comparable with those at a comprehensive stroke center. This can help minimize unnecessary transfers to the hub to only appropriate patients. This will, as a result, decrease the burden on the hubs and allow the stroke teams there to cover more spoke sites. Another benefit is patients will remain in the community for treatment, reducing the travel burden and costs associated with transferring care to an urban location. More efforts should be done to increase the number of spoke hospitals who are capable of admitting AIS patients after receiving tPA to achieve the goals mentioned above.

Our study has few limitations. The main limitation is driven by the retrospective nature of the study. Additionally, a relatively large number of patients were excluded due to absent 90-day mRS that could lead to bias. Finally, this is a single telestroke network study, and our results might not be generalizable.

## Conclusion

Our study shows no difference in the long-term functional outcome for patients who received tPA through telestroke consultation and remained at spoke hospitals (drip-and-stay) compared with patients who received tPA at the hub. This reflects a high quality of patient care following tPA administration and rehabilitation capability at spoke hospitals.

## Acknowledgments

Statement of compliance with the guidelines for human studies and animal welfare regulations; Authors confirm that

the study is an observational minimal risk study and no consent is required per the MUSC institute policy. Our study was approved by the Institutional Review Board of the MUSC.

## Disclosure Statement

The authors declare no conflicts of interest.

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*Received: May 16, 2018*

*Revised: July 14, 2018*

*Accepted: July 16, 2018*